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STORAGE

WINDROWING SUGARCANE IN THE NORTH-WEST FRONTIER PROVINCE

PART I

THE EFFECT ON THE ECONOMICAL AND AGRICULTURAL SITUATION

BY

W. ROBERTSON BROWN

Agricultural Officer, North-West Frontier Province

PART II

THE EFFECT ON THE COMPOSITION OF SUGARCANE

BY

W. H. HARRISON, D.Sc

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WINDROWING SUGARCANE IN THE NORTH-WEST FRONTIER PROVINCE.

PART I.

THE EFFECT ON THE ECONOMICAL AND AGRICULTURAL SITUATION.

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

[Received for publication on 17th May, 1920.]

WINDROWING is the term which has been adopted by the sugar-planters of Louisiana to describe their own method of preserving sugarcane from rapid deterioration after the leaves and buds of the cane have been killed by frost. In the American cane-sugar state, the mercury falls to 22–26°F. on one or more occasions in the course of almost every manufacturing season. Yet Louisiana produces over 200,000 tons of white sugar a year. In the sugarcane area of the North-West Frontier Province the mercury does not often drop below 28°F., and cane for the production of *gur* is not injured by four or five degrees of frost. But if the manufacture of white sugar is undertaken at Peshawar, it is possible that occasions might arise when windrowing would have to be done. A study of the American practice was therefore undertaken at the Peshawar Agricultural Station, and cane was first windrowed there in 1916.

Four seasons are recognized in the Peshawar valley : Spring in February, March and April. During the earlier part of this season there are occasionally light hailstorms, and, usually, rain falls to the extent of three or four

inches. Normals of temperature, derived from the data of 33 years, are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
	°F	°F	°F
February ..	65·7	42·5	54·1
March ..	75·0	51·7	63·3
April ..	85·5	60·3	72·9

Summer in May, June and July. Rain rarely falls during this season which is the hottest of the year. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
	°F	°F	°F
May ..	98·1	69·9	54·0
June ..	105·9	77·3	91·6
July ..	102·7	79·2	90·9

Autumn in August, September and October. The season is ushered in by the hot weather rains. They break over the valley in four or five violent storms at intervals of a few days, and two or three inches of rainfall on each occasion. During the first part of this season the sky is more or less overcast with clouds and the air is steamy and oppressive. Normals of temperature are as follows :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
	°F	°F	°F
August	99·2	78·0	88·6
September	95·6	70·5	83·1
October	88·2	57·9	73·1

Winter in November, December and January. During this season the weather is variable. The sky is at first hazy, then cloudy, with sometimes slight rain. There is a remarkable absence of wind generally, and the air is still and stagnant. The first touch of frost is expected towards the end of November. The mercury sometimes drops to 26°F., but usually not more than two or three degrees of frost is registered. Normals of temperature are as follows :—.

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
	°F	°F	°F
November ..	77·3	46·1	61·7
December ..	69·0	39·2	53·1
January ..	63·0	39·6	51·3

As the average annual rainfall is only about 14 inches, sugarcane is irrigated from 20 to 25 times during the period of its growth, which extends from April to the end of October.

Although sugarcane is known to have been cultivated in the valley for nearly a thousand years, only one variety is now grown on the area of 28,000 acres that is under the crop. It was introduced into the province more than fifty years ago, and it does not appear to have deteriorated in that time. It is a thick, soft, light-green and very juicy *Pounda* variety, yielding, under good cultivation, from 28 to 30 tons stripped cane per acre. Ratooning is not practised at Peshawar, the cultivators having found " plant " cane better and more profitable for *gur*.

The fields are planted in March, and increase in the weight of the cane ceases with the advent of the cold weather in late November. By the middle of December the cane fields are no longer green—the cane tops have been killed by frost—the leaves are yellow and dead. Usually, the lower buds of the cane are not killed by frost until some time in January : in a very mild winter these buds may not be injured. Nevertheless, as the buds of the cane are liable to be killed by frost, the growers have long been accustomed to " clamp" a certain amount of their crop to preserve it for seed. " Clamping " consists of digging up the cane with the surface roots, and laying the clumps with their leaves in a heap, which is covered with about four inches of soil. It is done in November, and the cane is perfectly preserved in this way until the time

for planting arrives in March. Outwardly, a cane " clamp " resembles a potato pit.

If a grower has " clamped " more cane than is required to plant his field, the surplus cane is crushed, and, usually, the *gur* made therefrom is not inferior to that produced from cane treated directly from the field. A series of analyses has shown that no deterioration occurs in cane which has been " clamped " from the 15th November to the end of March. But from a manufacturing point of view " clamping " is expensive. It costs fully one anna per maund to pit the cane and to take it out again. It was thought, however, that *if cane deteriorated as little in windrow at Peshawar as it does in " clamp " there, the practice of windrowing might be of considerable advantage to a sugar factory.* Windrowing is not an expensive operation. It consists of cutting the cane and laying it down, unstripped, where it was grown, the leaves forming a thatch which preserves the solid cane from the weather, and, more especially, from frost. A small amount of cane was accordingly windrowed at the Agricultural Station late in November 1916. In February, this cane, after lying exposed to the weather for three months, yielded first class *gur*. This was a surprising result, for almost wherever sugarcane is grown for the production of white sugar, and certainly in all the tropical parts of the so-called sugarcane belt, it is known that cane deteriorates more or less quickly directly it is cut.

From many points of view it would be a great advantage at times if a sugar factory could permit cane to lie in windrow for ten days or a month, with the knowledge that it would not deteriorate.

A scheme of investigations on a liberal scale was planned for 1917-18-19. In Part II of this Memoir the Imperial Agricultural Chemist, who carried out the tests, will state what results he obtained.

PART II.

THE EFFECT ON THE COMPOSITION OF SUGARCANE.

BY

W. H. HARRISON, D.Sc.,
Imperial Agricultural Chemist;

AND

P. B. SANYAL, M.Sc.,
Assistant to the Imperial Agricultural Chemist.

In Part I of this Memoir Mr. Robertson Brown has given an account of the effect of the practice of windrowing sugarcane in the North-West Frontier Province on the economical and agricultural situation, and in this part we propose to deal solely with the changes which occur in the windrowed canes from the point of view of the conservation of their sugar content.

On December 5th, 1917, a large average sample was drawn from a stand of the local *Pounda* cane, covering an area of one acre, and a careful analysis of the juice was made. The whole of the cane was windrowed on December 19th and allowed to remain in this condition until April 5th, 1918, when another average sample was drawn and analysed. The composition of these two samples is shown in Table I.

TABLE I.

Showing percentage composition of the juice from local Pounda canes before and after windrowing.

Component	Before windrowing on December 5th	After windrowing on April 5th
Average weight of cane lb. ..	2·39	2·12
Juice percentage	75·84	71·70
Sucrose percentage	9·57	13·25
Glucose percentage ..	2·38	2·74
Brix (corrected)	13·34	18·05
Coefficient of purity ..	71·70	73·41
Crystallizable sugar* ..	8·06	11·33

* "Crystallizable sugar" has been calculated from the formula $C = S\,(1{\cdot}4 - \frac{40}{P})$ when C = % crystallizable sugar; S = % sucrose; and P = purity of juice.

The effect of windrowing has been very marked. The weight of the individual cane (less tops and roots), and the percentage of the juice expressed, have decreased during this period, showing that there has been a drying up of the cane, and, as a consequence, the concentration of solids in the juice has considerably increased. The percentage of glucose has increased only to a slight extent, whereas that of the sucrose shows a very material increase. This is reflected in the fact that the coefficient of purity shows a decided increase.

It is therefore evident that the *quality* of the juice has improved and, consequently, the yield of sugar from equal weights of juice would be greater after the period of windrowing. Although the juice has not deteriorated it does not follow, however, that there has been no destruction of the sugars originally present in the cane, and this point can only be determined by comparison of the estimates of the sugars present in a given quantity of cane before and after windrowing. This comparison is made in Table II.

TABLE II.

Showing weights of juice, sucrose and glucose in 1,000 *lb. of cane at windrowing and the equivalent weight after windrowing.*

	Equivalent weight of cane	Weight of juice	Weight of sucrose	Weight of glucose	% GAIN OR LOSS		Crystallizable sugar	% loss or gain of crystallizable sugar
	lb.	lb.	lb.	lb.	sucrose	glucose	lb.	
Before windrowing ..	1,000	758·4	72·6	18·0	..	..	61·2	..
In March 1918..	887	636·0	84·3	17·4	+16·1	—3·3	72·1	+17·8

Thus not only is the quality of the juice higher after the period of windrowing but, in addition, the weight of sucrose and crystallizable sugar in the crop has been materially increased. This conclusion receives support from the analysis of a number of canes which had been allowed to remain in the ground throughout the cold season and which were analysed early in March. The comparison between the composition of these canes, those analysed in December and the windrowed canes in March, is set out in Tables III & IV.

TABLE III.

Showing the percentage composition of the juice of canes left in the field throughout the cold season until March 1918.

Average weight of cane lb.	2·62
Percentage juice expressed	77·86
Percent. sucrose	11·03
Percent. glucose	2·35
Brix (corrected)	15·26
Coefficient of purity	72·30
% crystallizable sugar	9·40

TABLE IV.

Showing weights of juice, sucrose and glucose in 1,000 *lb. of cane left standing until March* 1918.

Equivalent weight of cane lb.	1,096·0
Weight of juice lb.	853·6
Weight of sucrose lb.	94·1
Weight of glucose lb.	20·1
Weight of crystallizable sugar lb. ..	80·2
% increase in sucrose	29·6
% increase in glucose	11·7
% increase in crystallizable sugar ..	32·7

If the values obtained when the cane is left standing throughout the season are taken as representing the maximum attainable under Peshawar conditions then windrowing in December has led to a loss of 9·8 lb. of sucrose and 8·1 lb. crystallizable sugar for every 1,000 lb. of cane standing in December 1917. Consequently it would appear that the best plan would be to leave the canes in the ground as long as possible. This, however, is not practicable owing to the danger of considerable damage occurring through incidence of a "splitting frost."

Just before the windrowed canes were analysed and for several days afterwards there was heavy rain and it was noticeable that canes analysed after this period were inferior to those already considered.

TABLE V.

Showing inferiority of windrowed cane after a period of rain.

Juice		Crop	
Average weight of cane lb. ..	2·00	Equivalent weight of cane lb. ..	837·0
% juice expressed	72·00	Weight of juice lb.	602·6
% sucrose	12·41	Weight of sucrose lb.	74·8
% glucose	2·83	Weight of glucose lb.	17·1
% crystallizable sugar ..	10·50	Weight of crystallizable sugar lb. ..	63·2
Brix (corrected)	17·17	% increase in sucrose ..	+ 2·9
Coefficient of purity	72·27	Do. glucose ..	— 5·9
		Do. crystallizable sugar ..	+ 3·3

These differences were at first assigned to errors of sampling, but a similar depreciation in quality was met with in 1919 immediately after a period of heavy rain, and will be referred to in the sequel.

The conclusions which emerge from the experiments of the season 1917-18 are that the windrowing of cane permits of the cane being stored without deterioration during adverse climatic conditions, and is suitable for adoption in the North-West Frontier Province. At the same time it is noticeable that all the buds are killed, so that when it is desired to store cane for seed windrowing proves unsuitable and recourse must be had to clamping. This season's results, so far as they go, point to a very considerable synthesis of sucrose in the windrowed cane and were of such a striking character that it was decided to continue the investigation during the season 1918-19 on a larger scale.

With this object in view the sugarcane area was divided into three portions, the first of which was sampled and analysed on December 18th, 1918, and immediately windrowed. The second portion was sampled, analysed and windrowed on January 10th, 1919, and the third portion treated in a similar manner on February 3rd. It was possible, therefore, to institute comparisons between canes windrowed early and late, and, at the same time, by drawing samples the character of the changes which had occurred in the windrowed cane could be approximately determined at any moment.

Table VI gives the variations in the composition of the juice of the windrowed canes up to March 12th when the experiment was abandoned, and, when the difficulty of taking a number of representative samples from the same bulk of cane over comparatively long periods of time is taken into consideration, the results may be considered as fairly concordant.

TABLE VI.

Variations in the composition of the juice of windrowed canes.

A. CANES WINDROWED ON DECEMBER 18TH, 1918

Date	Days after windrowing	Average weight of cane lb.	% Juice expressed	Brix (corrected)	% Sucrose	% Glucose	Coefficient of purity	Glucose ratio	% Crystallizable sugar	% Non-sugars
Dec. 18th, 1918 ..	0	2·53	73·05	15·30	12·93	1·25	84·51	9·65	11·98	1·12
„ 24th „ ..	6	2·45	74·49	15·57	13·11	1·29	84·20	9·81	12·13	1·17
Jany. 1st, 1919 ..	14	2·63	75·24	16·38	13·71	1·36	83·68	9·90	12·66	1·31
„ 22nd „ ..	35	2·66	75·00	16·66	13·73	1·56	82·42	11·34	12·56	1·37
„ 31st „ ..	44	2·56	74·61	17·17	13·93	1·57	81·14	12·95	12·61	1·17
Feby. 6th „ ..	50	2·32	75·00	17·24	13·97	1·70	81·07	12·14	12·67	1·57
„ 20th „ ..	64	2·14	73·39	17·91	14·28	2·02	79·73	14·17	12·82	1·61
March 12th „ ..	84	2·14	70·56	18·63	14·29	2·21	76·72	15·47	12·57	2·13

TABLE VI—*concld.*

B. CANES WINDROWED ON JANUARY 10TH, 1919

Date	Days after windrowing	Average weight of cane lb.	% Juice expressed	Brix (corrected)	% Sucrose	% Glucose	Coefficient of purity.	Glucose ratio	% Crystallizable sugar	% Non-sugars
Jany. 10th, 1919 ..	0	2·25	74·43	15·23	13·11	1·23	86·08	9·32	12·26	0·89
„ 16th „ ..	6	2·31	72·22	15·74	13·42	1·10	85·25	8·27	12·49	1·22
„ 31st „ ..	21	2·42	72·52	16·19	13·19	1·25	81·45	9·49	11·98	1·75
Feby. 11th „ ..	32	2·24	74·32	16·37	13·47	1·46	82·28	10·83	12·31	1·44
„ 20th „ ..	41	2·01	71·73	16·16	13·24	1·59	82·01	12·01	12·08	1·33
March 12th „ ..	61	1·94	70·36	17·26	13·53	2·03	78·36	15·01	12·55	1·70

C. CANES WINDROWED ON FEBRUARY 3RD, 1919

Feby. 3rd, 1919 ..	0	2·64	76·89	14·95	12·91	1·03	86·36	7·99	12·09	1·01
„ 10th „ ..	7	2·42	74·68	15·38	13·11	1·03	85·21	7·89	12·20	1·24
„ 20th „ ..	17	2·24	68·44	15·82	13·23	1·04	83·65	7·86	12·20	1·55
March 3rd „ ..	28	2·08	71·50	15·75	13·29	1·24	84·34	8·82	12·30	1·22
„ 12th „ ..	37	2·08	73·56	15·69	13·17	1·40	83·96	10·65	12·16	1·12

The conclusions which emerge from a comparison of the values given in this table may be summarized as follows :—The total solids present in the juice, as measured by " Brix," increase during the whole period showing that the juice becomes more concentrated as time goes on, and, as this is accompanied by a decrease in weight of an average cane, it may be concluded that evaporation is one factor bringing this change about.

This change in the concentration of the juice is accompanied by increases in the percentages of the sucrose and glucose present, but the proportion of glucose tends to increase in amount more rapidly than the sucrose so that there is a falling off in the quality of the juice. This is clearly shown by the " coefficient of purity " and " glucose ratio " values but, notwithstanding this fact, owing to the increase in the concentration of the juice the variations in the percentage of crystallizable sugar obtainable are practically nil.

It would therefore appear that although windrowing under the Peshawar conditions tends to reduce the purity of the juice, yet, owing to the juice becoming more concentrated, the percentage of crystallizable sugar remains fairly constant and, therefore, *the practice of windrowing will not lead to any appreciable decrease in the amount of sugar obtained from equal weights of juice evaporated.*

Although windrowing is thus shown to increase the sucrose content of the juice, and not to depress the " crystallizable sugar " value, it does not follow that there is no loss of sucrose and sugar so far as the crop is concerned. This point can only be determined by making careful weighments of the cane taken for the samples and of the juice expressed, and from these figures calculating the values of sucrose, glucose, etc., present in equivalent amounts of cane at the different stages. In Table VII are given the values at the different dates calculated on the basis of the weight of cane equivalent to 1,000 lb. of cane at the time of windrowing.

TABLE VII.

Showing the variations in the amount of sucrose, glucose, etc., per 1,000 *lb. of cane at the time of windrowing.*

A. CANES WINDROWED ON DECEMBER 18TH, 1918

Date	Days after windrowing	Equivalent weight of cane lb.	Juice expressed lb.	Sucrose present lb.	Glucose present lb.	Crystallizable sugar present lb.
Decr. 18th, 1918..	0	1,000 0	730·5	94·40	9·13	87·4
„ 24th „ ..	6	968·5	721·4	94·60	9·31	87·50
Jany. 1st, 1919..	14	1,040·0	782·1	107·20	10·64	99·04
„ 22nd „ ..	35	1,048·0	785·5	107·90	12·25	98·68
„ 31st „ ..	44	1,016·0	758·0	105·70	11·98	95·57
Feby. 6th „ ..	50	917·0	687·8	96·08	11·69	87·16
„ 20th „ ..	64	845·8	620·8	88·64	12·54	79·60
March 12th „ ..	84	845·8	596·9	85·29	13·19	75·02

B. CANES WINDROWED ON JANUARY 10TH, 1919

Jany. 10th, 1919..	0	1,000·0	744·3	97·58	9·16	91·26
„ 16th „ ..	6	1,027·0	741·6	99·59	8·23	92·65
„ 31st „ ..	21	1,076·0	780·1	102·90	9·75	93·48
Feby. 11th „ ..	32	995·4	739·8	99·65	10·80	91·05
„ 20th „ ..	41	893·4	640·8	84·84	10·19	77·39
March 12th „ ..	61	862·2	606·7	82·08	12·32	76·14

C. CANES WINDROWED ON FEBRUARY 3RD, 1919

Feby. 3rd, 1919..	0	1,000·0	768·9	99·27	7·92	92·94
„ 10th „ ..	7	916·7	684·6	89·75	7·05	83·54
„ 20th „ ..	17	848·5	580·7	76·83	6·04	70·84
March 3rd „ ..	28	787·9	555·5	73·82	6·89	68·32
„ 12th „ ..	37	787·9	579·6	76·32	8·11	70·49

Showing the variations in the amounts of Glucose, Sucrose and Crystallizable Sugar present in windrowed Canes. Canes windrowed on December 18th 1918 _____ Canes windrowed on January 10th 1919..... Canes windrowed on February 3rd 1919_____

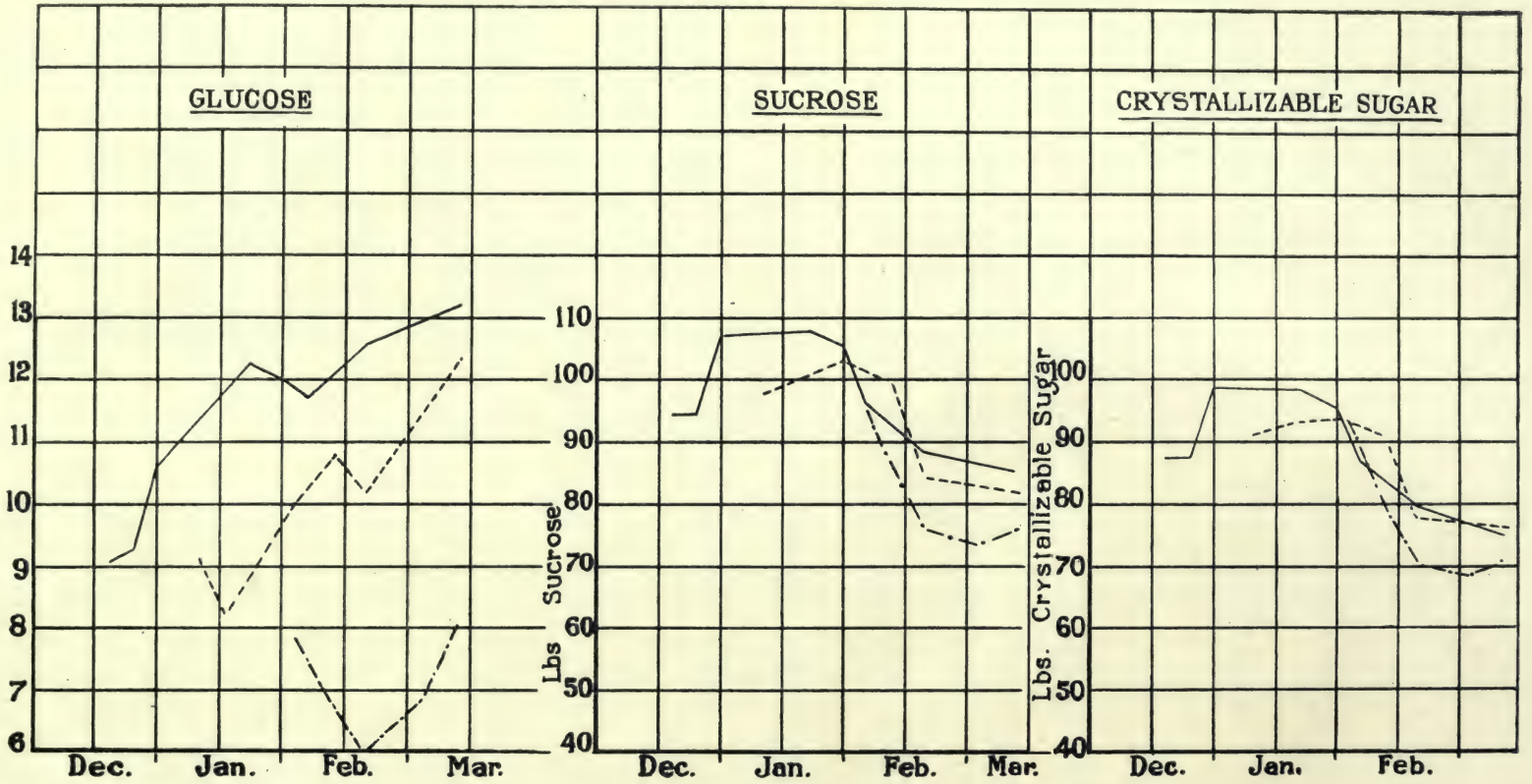

CHART I.

From a comparison of the results in this table it is evident that the amount of sucrose in the *crop* windrowed on December 18th, 1918, increases rapidly up to January 1st and then remains constant throughout that month, after which there is a rapid decrease. The cane windrowed on January 10th shows a similar increase at first and a rapid decrease after the first week of February, whereas the cane windrowed on February 3rd shows a continuous decrease. Thus, it is evident that cane windrowed in December and January more than maintained its sucrose content until early February and after that date both these canes and also those windrowed in February showed a continuous deterioration up to the end of the experiment.

This fluctuation in the quantity of one constituent of the windrowed cane is paralleled by (*a*) weight of the cane, (*b*) weight of juice expressed, and (*c*) is particularly well demonstrated in the case of crystallizable sugar. The only constituent which does not follow the general trend is glucose which, in general, increases in quantity throughout the whole period. These variations are shown graphically in Chart I in the case of sucrose, glucose and crystallizable sugar.

These comparisons clearly show that cane can be stored safely by windrowing under Peshawar conditions for a certain period after which rapid deterioration sets in. The date on which this occurs would appear to be the same whether the cane be windrowed early or late in the season and, consequently, would seem to be due either to biological factor solely connected with the cane, or to a seasonal one which affects all canes in similar degree. In this connection it may be pointed out that, whereas canes windrowed in December 1917 were in perfectly good condition and showed no signs of deterioration four months later, those windrowed in December 1918 and January 1919 could not be kept in good condition beyond the first week of February, and these facts would tend to show that the determining factor is a seasonal one.

This factor, or factors, is not easy of determination unless observations are extended over a series of seasons, but a comparison of the weather records for the season 1917-18 and 1918-19 for Peshawar shows that the mean temperatures from January to March were, in general, slightly lower during 1919 than 1918, and this would appear to throw out of court any question of temperature being the real determining factor which initiates the change. One comparison is, however, significant, and that is the date on which heavy rainfall was experienced. In 1918 no rainfall of any meaning occurred until late in March and the canes were quite good on April 5th, whereas in 1919 one heavy fall was experienced on January 30th and another on February 16th and deterioration was noticeable during early February. Both the temperature and rainfall comparisons are shown in Chart II.

It is possible that the incidence of heavy rainfall is the factor which determines the incidence of deterioration.

SUMMARY.

1. Storage of sugarcane by windrowing can be successfully carried out in the Peshawar valley.

2. Windrowing tends to cause the purity of the juice to deteriorate, but at the same time bring about a concentration of the juice with the result that the amount of " crystallizable sugar " per unit weight of juice remains approximately constant.

3. The weight of sucrose and crystallizable sugar contained in a crop of windrowed cane increases rapidly at first to be followed by a period during which the values remain practically constant, after which deterioration sets in.

4. The period during which canes can be stored varies with different seasons but in any particular season appears to be determined by the incidence of heavy rain.

Rainfall and variation of the mean Weekly Temperature.

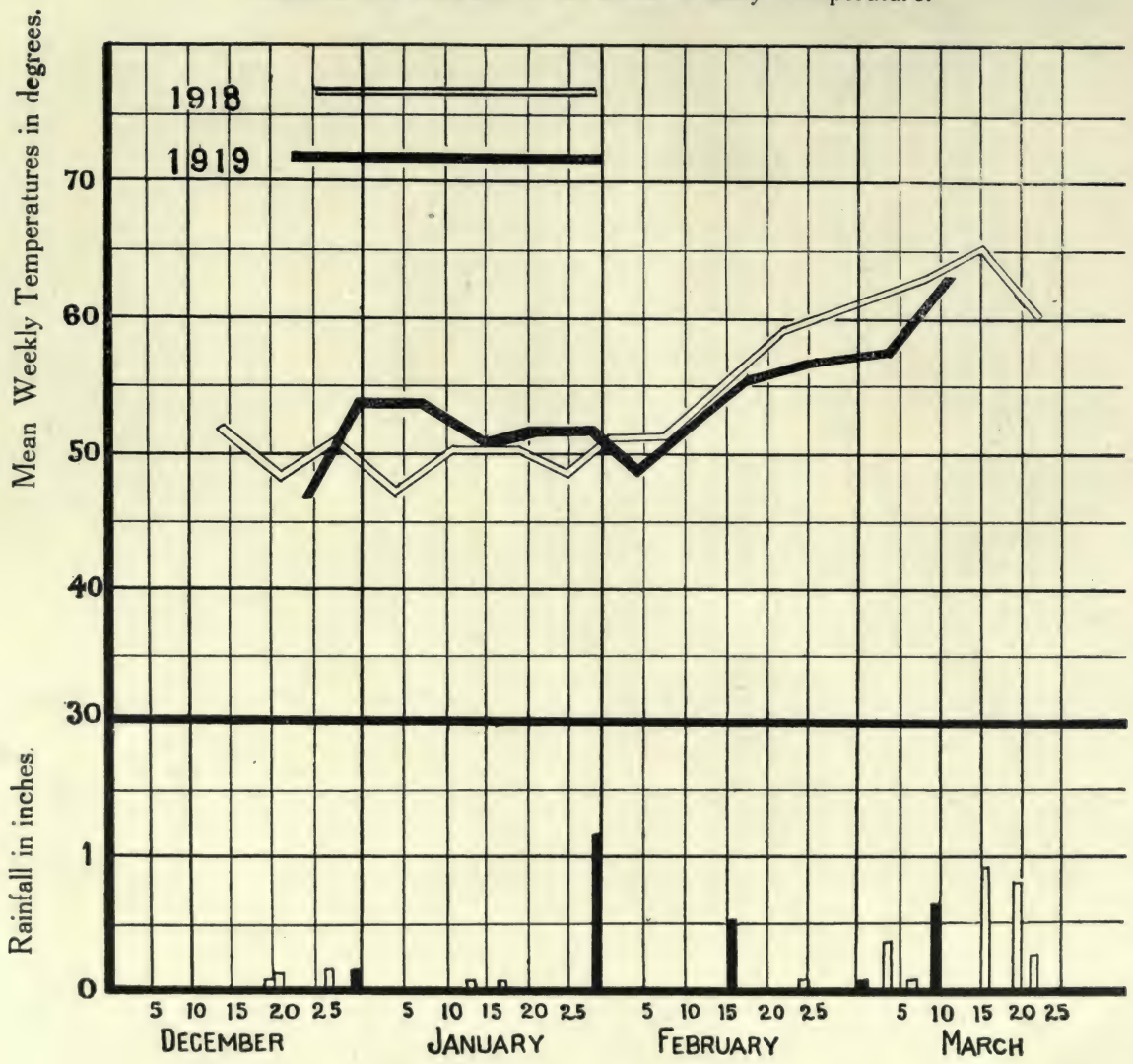

CHART II.

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